Mimicry in Spiders. By R. I. Pocock, F.L.S., F.Z.S., Superintendent of the Zoological Society's Gardens.

(Plate 32.)

[Read 3rd December, 1908.]

Introductory Remarks.

Although mimicry in Insects has received much attention during the past forty years, mimicry in Spiders has been comparatively speaking neglected. Isolated notices of particular cases, and general statements of the occurrence of the phenomenon in this order of Arachnida, are to be found here and there in zoological literature ; but in very few cases are details given, and as a rule no suggestion is made even as to the family to which the mimetic spider belongs. I have thought it useful, therefore, to collect together such records as are known to me and to make them the subject-matter of a special paper.

It is now nearly twenty years since Mrs. Peckham gave a most useful summary of previously published views and facts connected with this question and recorded some original observations of the highest interest upon two species of mimetic Salticidæ found in North America. But very considerable additions to our knowledge have been made since that time, notably by the publication of Mons. E. Simon's great work, 'Histoire Naturelle des Araignées,' Paris, 1892–1903. Although this work is mainly systematic and deals with the families and genera of Spiders, it also contains brief accounts of their habits ; and amongst the latter are to be found numerous records of ant-mimicry, giving in some cases the name of the model as well as of the mimic. These were based upon the author's own observations during his collecting trips to the tropics of both the Eastern and Western hemispheres. I have borrowed from this volume of Simon's most of the cases of ant-mimicry mentioned in the following pages. My acknowledgment of this fact in this place will save the repetition of references to his work in the text.

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Mimicry of Snails and Beetles by Spiders.

Amongst the Argyopidæ (=Epeiridæ) some species referred to the genus *Cyclosa* resemble small mollusca which, on account of the hardness of the shell, would be eaten by few birds and would certainly be neglected both by Pompilidæ and Ichneumonidæ, the principal enemies of Spiders, as unfit food for their larvæ. One species has been recorded from Ceylon *; another from North America †. The latter, when clinging to the underside of a leaf with its legs drawn up, is almost an exact copy in colour and shape of a small snail which is abundant in similar situations in the same locality during the warm months of the year. The resemblance is enhanced by the complete immobility the spider maintains when forcibly torn from its hold or when the plant is rudely shaken. According to Mr. Shelford ‡, another spider (*Cyrtarachne conica*) belonging to the same family, and recorded from Kuching in Borneo, also mimics a snail and has the habit of adhering to the underside of leaves. Other members of this family mimic ladybirds (Coccinellidæ). These beetles are known to be protected by a nauseous taste. Their short, oval, convex bodies, decorated above with yellow spots on a black ground or black spots on a yellow ground, are closely copied both in form and colour by certain tropical species; *e. g.*, by *Araneus coccinella*, *Paraplectana thorntoni* and *P. walleri* (Pl. **32**. figs. 6, 7, 8), by some East-Indian species of the last-named genus (*P. coccinella* and *P.* 12-*maculata*), as well as by other species from Brazil and elsewhere. According to Mr. Guy Marshall, *Paraplectana thorntoni* is, when living, coral-red with black spots, and mimics very exactly a Coccinellid (*Chilomenes lunata*) common in Natal §; and it was possibly one of the two above-mentioned Oriental species of the genus *Paraplectana* that Mr. Shelford ‖ cited as mimicking in Borneo the Coccinellid *Caria dilatata*.

It is probable that most if not all hard-shelled beetles, whether nauseous like the Coccinellidæ or not, are avoided by a majority of insectivorous animals; and it is still more probable that they are unsuitable articles of diet for the comparatively weak-jawed larvæ of Pompilidæ and Ichneumonidæ. Hence the reason for the imitation of little beetles by the genera *Coccorchestes*, *Homalattus*, *Rhene*, and other Spiders belonging to the Salticidæ.

The imitation of short, squat, and compact beetles is probably general and not of particular species of these insects. The resemblance to them displayed by the mimetic spiders is due to the coloration or metallic hues of the thickened integument, to a shortening of the legs, and to the expansion of the cephalothorax and abdomen—the one frequently overlapping the other, and thus leading in appearance to the partial obliteration of the narrow waist-like constriction between these regions which is so characteristic a feature of most spiders. Modifications of the same kind, accompanied by the acquisition of a yellow and black pattern, are instrumental in producing the likeness to Coccinellidæ, above referred to.

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* O. P. Cambridge, Encycl. Brit., Arachnida, p. 299 (noted by Col. Yerbury).

† G. F. Atkinson, Amer. Nat. 1888, p. 545.

‡ P. Z. S. 1902, vol. ii. p. 265.

§ See Pocock, Ann. Mag. Nat. Hist. (7) vol. ii. p. 213, 1898.

‖ P. Z. S. 1902, vol. ii. p. 268.

Mimicry of Ants and Mutillas by Spiders.

Apart from beetles, the only insects known to me to be mimicked by spiders are ants; but so numerous and perfect are the instances of ant-imitation that all other examples of mimicry amongst spiders sink into insignificance beside them. It is in this category, indeed, that occur some of the most complete illustrations of mimicry yet discovered.

The structural variations that effect this end take quite a different direction from those presented by the spiders that mimic beetles. Ants as a group are very uniform in build. They are characterized by a peculiar elegance of shape, marking them off from all other animals except their imitators. The head is large, the neck slender and mobile; the thorax and abdomen, often themselves constricted, are connected by a narrow waist; the legs are slender; the antennæ, projecting from the front of the head, long and bent. The movements of these insects are stamped by a certain boldness and intelligence which impart an unmistakable individuality to them. The chief difference in outward form between a spider and an ant lies in the absence of antennæ and the possession of four pairs of legs, instead of three, in the spider, and in the fact that the fore part of the body is covered by a continuous shield or carapace and is not differentiated into "head," "neck," and "thorax." In the more perfect instances of mimicry the last-mentioned difficulty has been met by the formation of a distinct constriction on each side of the spider's carapace, dividing it into an anterior part representing the head, a narrow intermediate part representing the neck, and a posterior part representing the thorax of the insect. In many cases the appearance of slenderness about the neck is increased by a strip of white hairs on each side of the constriction, which has the optical effect of cutting out an extra piece of the integument. The waist of the ant is reproduced by the conversion of the end of the carapace, and often of the anterior end of the abdomen, into a narrow stalk. In some cases the abdomen is itself shallowly constricted, and even the abdominal segments of the insect may be represented by transverse bands of hairs. The legs are always slender, like those of an ant, and one of the anterior pairs is held up in front of the head as a substitute for antennæ. Finally, in many cases where observations of the living animal have been recorded, it has been found that the spiders carry the deception to the extent of copying the manners and gait of the insects. Several observers have testified to this fact. In 1879, the Rev. O. P. Cambridge * pointed out that the Clubionid, *Micaria scintillans*, presents the closest resemblance to a large black ant [*Formica rufibarbis*] with which it associates.

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* 'Spiders of Dorset,' p. 13; see also H. Donisthorpe, 'The Zoologist,' 1908, p. 424.

Two North-American species of Salticidæ (*Peckhamia picata* and *Synemosyna formica*) have been closely studied by Mrs. Peckham *, who states that the former presents a general resemblance to ants of two or three species with which it associates indiscriminately. Like an ant, when hunting for prey, the spider always zigzags from side to side in its walk and holds up the legs of the second pair in front of the head to simulate a pair of antennæ. Instead of standing still while feeding, as most spiders do, this spider keeps up an incessant twitching of the abdomen, pulling about its prey in different directions the while, beating it with its fore legs, and imitating to the life the restless movements of an ant when similarly engaged. *Synemosyna formica* behaves in exactly the same way as *P. picata*, although without mimicking the zigzag walk of the ants.

A few more records may be quoted. In the Oriental Region there is a common red-and-black tree-ant, *Sima rufo-nigra*. It is pugnacious and fearless, attacking without hesitation almost any animal it meets. On human beings the effects of its bite are both painful and lasting. Wherever these insects occur in any numbers, a species of spider [*Myrmarachne providens*], one of the Salticidæ, is to be found running about amongst them. The spider closely resembles the ant in form and colour. It appears to be on the most friendly footing with its formidable associates, moving quickly here and there in their company and copying their busy, hurried actions †. Again, there is in India a spider, of unknown identity, almost indistinguishable from the female of an ant, *Camponotus opaciventris*, whose mode of progression by a series of rushes and pauses the spider imitates closely; and in the neighbourhood of almost every strong colony of another ant, *Cremastogaster contenta*, a mimicking spider is to be found, moving about at a jog-trot and waving its abdomen in the air in exact imitation of the actions of its model. Again, in South Africa Mansell Weale ‡ discovered two species of Attidæ which bear the closest resemblance to ants. One is smooth, black and shining, and runs rapidly over the ground and on the bark of trees, and resembles an ant that builds its nests on acacia-bushes. The other is larger and has its cephalothorax dull black and its abdomen covered with short yellowish hairs. It is generally found running on the stems of herbaceous plants, and closely imitates an ant found in similar situations. The fore legs in both are frequently held up so that they closely resemble the antennæ of an ant.

As might be expected, ant-mimicry is of much commoner occurrence amongst ground-living species of spiders, belonging to the so-called "wandering tribes" which spin no snare, than it is amongst the snare-spinning sedentary groups. Instances, however, are not unknown amongst species of the latter kind.

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* Occ. Papers Nat. Hist. Soc. Wisconsin, 1889, pp. 110–113.

† Rothney, J. Bombay Nat. Hist. Soc. vol. v. p. 43, 1890.

‡ 'Nature,' 1871, p. 20.

In the Argyopidæ the males of the tropical American genus *Micrathena* (*Acrosoma*) differ strikingly from the large, gaudily (warningly) coloured, spiny females in having the abdomen black, slender, oval and elongated. In the males of *Ildibaha mutilloides* (Pl. **32**. fig. 1) and *myrmicæformis*, belonging to a genus closely allied to *Micrathena*, the abdomen is smooth, unarmed, deeply constricted in the middle, globular behind and oval in front of the constriction, where it meets the carapace which is itself narrowed behind. In an allied species, *I. albomaculata,* the abdomen is simply oval and without constriction. In butterflies it is common for the females alone to mimic a protected model, because being larger and heavier than the males and compelled to alight and remain at rest during oviposition, they are exposed to greater dangers of capture. This is reversed in the case of the spiders above mentioned. The females have a protective armature of spines and live in webs from which they can drop at once into the herbage beneath and lie absolutely still, hidden from the enemy that has startled them. But the males are not only without the spiny armature, but are compelled by the pairing instinct to wander about in search of the webs of the females. Another spider of this family, namely *Melyciopharis cynips,* is said by Simon to resemble ants. The thorax is attenuated behind, the waist is strongly pronounced, and the abdomen is globular. It is a native of the Amazons.

Formicina, one of the Linyphiidæ, a group which should probably be united with the Argyopidæ, has the carapace very narrow and long behind and the cephalic region high and shining ; the abdomen is globular but not coriaceous, and the legs are long and slender. The spider lives on the ground and spins a large horizontal web amongst grasses or other low herbage. It occurs in South Europe and has a nearly related ally (*Solenysa*) in Japan. Both are ant-like.

The Theridiidæ furnish a few examples of this phenomenon, all met with in South America. *Formicinoides* has the carapace long, low, and produced far beyond the posterior legs in the form of a narrow cylinder where it passes into a short pedicel or waist connecting it with the abdomen, which is high. *Cerodida* much resembles the foregoing, but has the abdomen short and globular. In *Audifia* the carapace is also long, oval, and narrowed behind, but does not surpass the posterior coxæ ; the abdomen is globular, with a hard shining smooth integument.

Coming now to the sedentary species, the Eresidæ furnish an instance analogous to that of *Ildibaha* mentioned above. In most species of this family the secondary sexual characters are well marked, especially as regards colour. But only in the case of the South-African genus *Seothyra* has an explanation of the difference been offered. The females of this spider (*Seothyra schreineri*) live in burrows in sandy parts of the veldt. The immature and moulting males have similar habits and, like the females, have the carapace and legs light brown and the abdomen smoky. But the adult males roam about the veldt by day and are totally different in colour, imitating in this particular as well as in movement the smaller specimens of a large vicious ant (*Camponotus fulvopilosus*) which is common in the locality. This similarity is not apparently effected by any special structural modification, the fore part of the carapace being normally rounded and rather sharply differentiated from the posterior portion, thus giving to the carapace a constricted appearance suggesting the head and thorax of an ant—the narrow waist, small abdomen, and longish slender legs of the spider, carrying the body well off the ground, completing the resemblance to the insect. The latter, like the spider, has the carapace and legs black, and moves in a series of rushes *.

In the Drassidæ two instances of mutilloid mimicry have been noticed in Rhodesia by Guy Marshall †. The species are *Melanophora* (*Prosthesima*) *albomaculata* and *Titus lugens*, which present a general resemblance to Mutillas.

Mutilloid mimics are also found in *Cœnoptychus* and *Graptartia*, two Ceylonese genera belonging to the family Clubionidæ. Both colour and shape combine to effect the likeness. The carapace is red in colour, rounded above and parallel-sided; while the abdomen, like that of the above-mentioned Drassidæ, is black and ornamented with white spots. This family—the Clubionidæ—furnishes some of the most perfect cases of ant-mimicry known, the most specialized forms of all being referable to the South American genus *Myrmecium*. The carapace is marked by a deep constriction behind the point of insertion of the legs of the second pair—the part in front of the constriction representing the head, and the part behind it, which is long and narrow and laterally bilobed, the thorax of the ant. The posterior extremity of the carapace is prolonged into a narrowed neck, which with the pedicel and a similar short prolongation from the abdomen exactly reproduces the waist of the insect. The abdomen is evenly oval or shallowly constricted. The colour varies according to the species of ant that is imitated. *Myrmecium nigrum* (fig. 3), which mimics *Pachycondyla villosa*, is black and clothed with close-set yellowish-green pubescence, and the abdomen is marked behind with transverse bands simulating segmentation. Other species are yellow or red, with the abdomen striped brown or black, to resemble species of *Megalomyrmex*. Others are black with yellow legs, in imitation of ants of the genera *Atta* or *Anochetus*; others, entirely brown and furnished with extra pubescence, reproduce exactly the form and colour of *Dendromyrmex fabricii*.

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* C. C. Schreiner, Pop. Sci. Monthly, Dec. 1902, p. 162; Purcell, Ann. S. Afr. Museum, 1903, p. 32.

† Tr. Ent. Soc. 1902, p. 511.

Some species of the genus *Castaneira* (e. g., *C. tenuiformis*) from Paraguay, which mimics *Pachycondyla*, have the carapace very long and marked on each side by a deep groove forming a constriction behind the square cephalic portion. The legs are either spotted or annulated.

Somewhat similar are the species of *Corinomma* from the Oriental Region, which have the constricted carapace of the above-mentioned genera, with the integument black, olive, or red in colour and clothed with variously coloured plumose hairs forming transverse segmental zones on the cylindrical abdomen. The genus *Psellocoptis* contains large and handsome spiders from Venezuela, where they are found running rapidly over the trunks of trees. They are clothed with thick plumose pubescence, forming elegant yellow and white patterns on a black ground. The species of *Apochinomma* also closely resemble ants. The integument is generally black and shagreened and clothed with scaly, plumose, or simple white or yellow hairs, forming segmental belts on the abdomen. The carapace is long, rounded or truncated in front and attenuated behind; the abdomen is sometimes globular, with a long anterior stalk-like prolongation, sometimes cylindrical, with usually a lateral constriction. *Sphecotypus niger* (fig. 2) differs principally from *Apochinomma* in having a deep cephalothoracic constriction. It is a large blackish species common in the forests of tropical America, where it mimics *Pachycondyla villosa* even more closely than does *Castaneira tenuiformis.*

Two striking instances are found amongst the Thomisidæ *. *Aphantochilus* has the integument horny, granular, and black or brown in colour and shining; the carapace is squared and round with a spine on each side in front, and is narrowed and pointed behind, with a shallow lateral constriction. The abdomen is oval, marked with transverse integumental folds and studded with transverse rows of pale bristles which simulate segmentation. The palpi are tucked away beneath the edge of the carapace, and the four pairs of legs representing the antennæ and legs of the ant are long and slender. During life the species of this genus, which occurs in Venezuela and Brazil, offer a striking resemblance to ants of the genus *Cryptocerus.*

Amyciœa forticeps (figs. 5–5 *a*) mimics and lives in company with the little red spinning ant, *Œcophylla smaragdina*, a common Oriental species. The colour of the spider is orange-red, relieved by a pair of black spots at the end of the abdomen. The carapace is high and rounded in front, but narrowed and prolonged behind. The abdomen is very different from that of the typical Thomisidæ, being cylindrical and elongated, rounded in front and behind, with a shallow median constriction, and leaves the carapace uncovered in front. The high and rounded cephalothorax of this spider represents the abdomen of the ant, the waists of the two correspond, and the long, constricted abdomen of the spider with the large black spots at the end, imitate the thorax, head, and two eyes of the ant. Thus the posterior end of the spider corresponds to the anterior end of the ant, an anomaly no doubt connected with the habit, so characteristic of the Thomisidæ, of moving sideways and backwards with almost greater facility and frequency than forwards.

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* These two cases of ant-mimicry were detected by Simon, Hist. Nat. Araignées, vol. i. pp. 957 & 988, 1895.

A second species of *Amyciæa*—*A. lineatipes*—has been discovered at Singapore also associated with *Œcophylla smaragdina*. It is a much less perfect mimic than *A. forticeps* because the abdomen is shorter, oval, and not constricted, so that the head and thorax of the insect are much less clearly indicated *.

Amongst the Salticidæ (Attidæ) are found species presenting every grade of ant-mimicry, from forms like *Peckhamia picata* which imitates ants in general, to the numerous species of *Myrmarachne*, in which, in many cases, the mimicry of particular species of these insects is carried to a state of perfection equal to anything found in the Clubionidæ. It is needless to give a complete list of all the genera that furnish illustrations of this phenomenon, since the structural modifications which combine to produce the resemblance are in all essential respects of the same nature in all, and differ in no important respects from those already described in the Clubionidæ and other families. An exception to this, however, is furnished by the males of some of the species of *Myrmarachne*, in which the elongated mandibles share in producing the required effect. For instance, in *M. plataleoides* (fig. 4)—a Ceylonese species which, like *Amyciæa forticeps*, mimics and associates with *Œcophylla smaragdina*—the mandibles, which are stretched straight forwards in front of the head, are narrow in their proximal half and swollen distally, and are furnished with a pair of black spots said to resemble the eyes of the ant. In this species and many others of the genus, both carapace and abdomen are constricted and the pedicel is elongated. In others the abdominal constriction is absent, and the thoracic varies much in depth. The genus *Myrmarachne* contains some seventy or eighty species, and is distributed over all the warmer temperate and tropical countries of the world. The species vary much in colour to accord with that of the models they live with and copy. A tolerably common Oriental species is *M. providens* which mimics *Sima rufonigra*; another in Venezuela mimics *Anochetus emarginatus*. Even in England the genus is represented by *M. formicaria*, which occurs with species of the genera *Myrmica* and *Formica* †. Of the remaining genera the following may be mentioned:—*Bocus* from the Philippines, differing only from *Myrmarachne* in the method of constriction of the sternum, which is expanded between the coxæ of the first and second legs instead of between those of the second and third pairs; the Neotropical *Sarinda*, *Erica*, and *Fluda*, which have the constriction of the carapace somewhat shallow; *Simonella* and *Synemosyna*, in both of which the carapace is deeply constricted, the abdomen being evenly oval in the latter and very long and deeply subdivided in the former. The species of these genera are said to show special resemblance to ants of the genus *Pseudomyrmex*. In addition, there are the Neotropical *Zuningia* with its allied genera; the European *Synageles* and *Leptorchestes*; *Semora*, *Semorina*, *Bellota*, &c. from South America, and *Agorius* from the Oriental Region—all of which and many others exhibit in various degrees a mimetic similarity to ants, their colours naturally varying in conformity with that of their models, being coppery, black, yellow, or black and red, diversified with hairs of various hues.

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* O. P. Cambridge, P. Z. S. 1901, p. 14, pl. 5. fig. 4; also Shelford, P. Z. S. 1902, p. 266.

† H. Donisthorpe, 'The Zoologist,' 1908, p. 424.

A very interesting observation, perhaps throwing some light upon the origin of ant-mimicry, was made many years ago by that keen naturalist Burchell, who, as recorded by Prof. Poulton, affixed a MS. label to a spider—one of the Salticidæ—he collected in South America, stating that its movements were like those of an ant. Now the spider itself, although small and dark-coloured, is not ant-like. This suggests that imitation of the movements of ants may have been the first modification of survival value, at least in some of the many cases of ant-mimicry above recorded.

Explanation of Ant-mimicry in Spiders.

It has been suggested more than once that ant-mimicry in the case of spiders is for purposes of aggression, the spiders being enabled by their resemblance to ants to live without detection in the colony and prey upon the insects, which mistake them for members of their own kind; and Mr. Shelford, in the paper already quoted, speaks of this explanation as the true and accepted one. I cannot bring myself to believe that this is so, in spite of the admitted fact that ant-like spiders have occasionally been seen to kill and eat their insect models.

Ants appear to be guided by other senses than sight in detecting friend from foe; and, as Mrs. Peckham has pointed out in this connection, are not deceived when an individual of their own species, exactly resembling them so far as we can see, but belonging to another colony, is introduced into a nest. That the spiders are permitted to consort with the ants is a puzzling phenomenon, and proves, in my opinion, that the similarity between them is much more deep-seated than we can perceive; but in what the similarity consists, unless it be "feel" and "smell," I am unable to suggest.

It is known, moreover, that insects of various orders—Orthoptera, Homoptera, and Lepidoptera (larvæ)—mimic ants, and it cannot be claimed that in these cases the mimicry is aggressive. If it is protective, as there are very strong grounds for believing, similar mimicry on the part of spiders is also probably protective. At all events the reasons that can be brought forward in support of the view that ant-like grasshoppers, bugs, and caterpillars are protected by their resemblance to these Hymenoptera, can be used with equal cogency to explain the ant-mimicry of spiders. There is no proof that ant-like spiders habitually feed upon the insects they mimic; but if this be shown in the future to be the case, I must still think that it is a secondarily acquired habit that has arisen subsequently to and independently of the superficial similarity in shape, colour, and gait between the two groups of arthropods.

Apart from the evidence supplied by the independent attainment of an ant-like form by a large number of spiders belonging to widely divergent families, strong testimony in favour of the protective usefulness of the resemblance can be brought forward.

An item of indirect evidence pointing to this conclusion is the fact that at least some of the spiders thus modified are known to produce at birth a very small number of young. According to Mrs. Peckham the ant-like spiders of North America have lower fecundity than any other group of spiders. *Peckhamia picata*, for example, lays only three eggs at a time. Since fertility is a measure of mortality, this exceptionally low birth-rate proves that the species is especially protected in some way; and since the spider is small, weak, and unprovided with special means of defence, it is justifiable to regard its survival, despite its infertility, as due to its likeness to ants. On the other hand, it may be asked, is there any direct evidence that ants are immune to the attacks of the enemies of spiders? A confident answer in the affirmative can be given. Ants are believed to be partially protected by an acid taste and are known to be able to bite and sting. They are also protected by their numbers and pugnacity, and are small, wiry, comparatively innutritious, and not worth the taking where other insects are to be had for food, except indeed by the comparatively small number of specialized vertebrate ant-eaters which are alleged to lick them up by the score [*].

But whatever may be the reason, it is nevertheless a fact that ants are not preyed upon to any great extent at all events by other insects. Mrs. Peckham [†], too, found that of the large numbers of Salticidæ kept by her in captivity none would touch ants, though they quickly devoured other insects and also spiders even of their own kind.

Most important of all is the fact that the solitary digger- or mason-wasps, the most inveterate enemies of spiders, scarcely ever, so far as I can ascertain, provision their cells with ants [‡]. Some species, indeed, have been stated to evince a positive aversion to these insects. Horne [§], for example, says that in India the red spinning ant (*Œcophylla smaragdina*), which I may add is mimicked in Singapore by two, possibly by three species of spiders and also by the larva of a Noctuid moth, attacks the wasps of the genus *Polistes*, to which it has great antipathy ; and to this Rothney * adds that these two kinds of Hymenoptera are never found inhabiting the same tree. Again, writing of *Pompilus fuscipennis*, Mr. & Mrs. Peckham † say that it "was one of the most fearless of the wasps .... the approach of an ant would throw her into a perfect panic, and seizing her spider she would make off with every sign of terror. It is difficult to understand why wasps of this species, as well as *P. biguttatus*, never offer combat to the ants, which rob them right and left, but invariably seek safety in retreat."

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[*] In this connection it is very necessary to bear in mind the confusion that is commonly made between ants and white-ants (Termitidæ). I suspect that many of the so-called "ant-eaters" like *Myrmecophaga*, *Manis*, and *Orycteropus*, have been so styled largely on account of their termite-eating propensities.

[†] Occ. Papers Nat. Hist. Soc. Wisconsin, 1889, p. 107.

[‡] One of the Crabronides (*Fertonius luteicollis*) preys upon ants in Algeria—see D. Sharp, Insects, pt. ii. (Cambr. Nat. Hist.) p. 130, 1899.

[§] Trans. Zool. Soc. vii. p. 171, 1872.

Now many of these wasps feed their larvæ solely upon spiders. When the time for egg-laying approaches, the female, aided sometimes by the male, starts hunting for spiders, flying in and out amongst the bushes and scouring every inch of ground, every nook and corner in her eager search. Few spiders when once found have much chance of escape from an enemy so swift of wing, so keen of sight, strong enough to carry many times her own weight, clad in a coat of horny mail and armed with a dagger-like sting and virulent poison. Some spiders succumb with scarcely a struggle ; some trust to speed of foot and run for their lives ; some when caught fight to the last. But the end is always the same. The wasp rises from the encounter victorious, and bears away her spoil in triumph to the mud-cell or burrow specially prepared for the purpose. When the receptacle is filled with carcases, the wasp lays an egg amongst them, closes up the mouth of the tomb, and starts afresh to provide for the rest of her brood in a similar manner. The number of spiders sacrificed for each larval wasp varies according to their size from one, as in the case of the large Aviculariidæ and some Lycosidæ, to many. In the United States, for example, *Sphex cyanea* commonly encloses from twenty to thirty or even forty in a single cell ‡. In West Africa Monteiro § counted as many as twenty, and found that there were seldom fewer than three cells together and often as many as eight or ten, all apparently made by the same wasp. Evidence of a like kind might be quoted without end from the works of travellers and naturalists. Nothing, however, more forcibly attests the extent of the destruction of spiders by these wasps than the following observation by G. W. Peckham ‖, which may be quoted verbatim :—"Years ago, when we found that many of the Epeiridæ [Argyopidæ] laid enormous numbers of eggs (*Argyope cophinaria* from 500 to 2000), we wondered what became of the thousands of spiderlings. An acquaintance with *Trypoxylon* has shown us their fate, and has given us an illustration of how closely the two groups are related. To make a very modest estimate there must have been twenty wasps at work in our straw stack. During the six weeks which make the busiest part of their working season each of these must have stored, at the very least, thirty cells, putting an average of ten spiders into each cell. It may then be considered certain that the straw stack was the mausoleum of six thousand spiders, and it is very probable that twice as many were interred within its depths. It must be remembered, too, that before the spiders have grown large enough to be interesting to *Trypoxylon rubrocinctum*, *T. bidentatum* has had her turn at them, and that those that are allowed to grow too large for *T. rubrocinctum* are preyed upon grade after grade by *T. albopilosum* and finally by *Pelopæus*, *Pompilus*, and other genera." The conclusions embodied in this passage were based, be it noted, upon observations made in a small and circumscribed area in temperate North America. It is justifiable to conclude that persecution at least as dire and destructive in its effects has been carried on season after season probably for many thousand years in all tropical and temperate countries where Pompilidæ and Spiders occur ; and setting aside the frigid zones of the world, the distribution of the two groups is practically cosmopolitan. This being so, it seems to be absolutely certain that wasp-persecution has had perhaps a greater effect in moulding and developing the structure and protective instincts in spiders than any other factor in organic nature ; and I am convinced it supplies the clue to many otherwise puzzling facts in spider economy. However that may be, the ascertained facts that the Pompilidæ do not provision their nests with ants, and that some of the species that persecute spiders have special antipathy to these little insects, furnish convincing evidence of the survival value of ant-mimicry to spiders *.

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* Journ. Bombay Nat. Hist. Soc. v. p. 51.

† 'The Solitary Wasps,' p. 142.

‡ Hentz, 'Spiders of the United States,' p. 122.

§ 'Angola and the River Congo,' p. 324.

‖ 'The Solitary Wasps,' p. 87.

Let me not be misunderstood to suggest that it is only from the Pompilidæ that spiders are saved by this form of mimicry. I have no doubt that it protects them also from the attacks of other enemies, notably from Ichneumon flies of the genera *Hemiteles*, *Polysphincta*, *Acrodactylus* and others, as well as from various insectivorous mammals, birds and reptiles. But although the annual mortality in the spider-world caused by these enemies, especially by the Ichneumonidæ, is no doubt considerable, it probably sinks into insignificance beside that brought about by the mason and digger wasps. The view here advocated that ant-mimicry in spiders is protective was long ago insisted upon by Belt as well as by H. H. Smith †. But I am not aware that the special advantage the mimetic species derive from being avoided by Pompilidæ and Ichneumonidæ has hitherto been pointed out *.

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* Since some species of the solitary wasps prey upon grasshoppers and other insects, this suggested explanation of the value to spiders of their resemblance to ants applies also to the ant-imitators found amongst Orthopterous, Homopterous, and other insects.

† See Peckham, Occ. Papers Nat. Hist. Soc. Wisconsin, 1889, p. 108.

Two conclusions appear to me to emerge very clearly from a study of the genuine cases of mimicry in Spiders.

1. There is no reason to suppose that any of the mimetic species are themselves specially protected in any way or inedible. Therefore their imitation of other animals that are avoided by the enemies of spiders is mimicry in the Batesian and not in the Müllerian sense of the word. In other words it is true mimicry.

2. Since it can be shown that the mimicry has in every case a survival value, the modifications that have brought it about fall within the scope of Natural Selection.

Doubtful cases of Mimicry in Spiders.

The instances of mimicry already cited in this paper cannot in my opinion be questioned. The same assurance cannot, however, be held about the following cases.

A possible case of protective mimicry in nest-building is furnished by the burrow of *Dolichoscaptus inops*, a species of the Cyrtaucheniinæ that lives in Algeria. Round the aperture of the burrow is erected a low chimney rising to half an inch or more in height, and consisting of silk stiffened with débris of various kinds which conceals the silk and makes the burrow resemble those formed by the solitary bees *Odynerus* or *Anthophora* †.

The advantage the spider derives from this resemblance, it may be suggested, lies in the immunity these bees enjoy to the attacks of mason-wasps, for the latter, mistaking the spider-burrows for those of the bees, would pass them by without further enquiry. But until it is definitely established that the nests of the bees occur in the same locality, the evidence for the view above stated remains unsatisfactory.

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* Although not strictly speaking belonging to the subject-matter of the present paper, the following observation is, I think, worth putting on record.

While watching one of the solitary digger-wasps at work last summer hunting for spiders with which to provide her larvæ, I saw her dislodge from a cranny between two stones an immature specimen of a species of *Phalangium*, possibly *P. cornutum*. She ran swiftly in chase of the Arachnid, but the moment she touched it with her antennæ turned aside and let it go. Although it is well known that the Phalangidæ possess stink-glands opening one on each side of the cephalothorax, which have been held to be of protective significance, I am not aware of any recorded evidence of their being rejected by the enemies of spiders. Certainly no instance of this has previously come under my own notice. It is possible of course that the wasp may have rejected the *Phalangium* for other reasons; but I think the escape of the Arachnid may be regarded as probably due to its inedibility owing to the smelling secretion it exudes.

† Simon, Actes Soc. Linn. Bordeaux, xlii. p. 394, pl. 12. fig. 5, 1887.

Prof. Poulton * long ago suggested that the larvæ of two British species of Hawk-Moths (*Chœrocampa elpenor* and *porcellus*) are protected by the likeness to the heads of snakes presented by their anterior extremities which are ornamented with large eye-like spots. The correctness of this surmise has been subsequently substantiated in the case of these two species by Weismann and Lady Verney, and the interpretation has been extended to other species of the genus *Chœrocampa*, namely, to *C. osiris* by Mr. Guy Marshall † in S. Africa, and to *C. myodon* by Mr. Shelford ‡ in Borneo. The experimental proof of the truth of Prof. Poulton's view justifies the acceptance as a working hypothesis of the suggestion put forward by Mr. Saville Kent § that the Australian Argyopid, *Pœcilopachys bispinosa*, is protected from attack by the similarity its abdomen presents to a reptile's head. The cephalothorax of this spider is small ; but the abdomen is of large size, wide, subtriangular in form, broad in front, gradually narrowed behind and flattened above. Its integument is a delicate mottled lilac hue, with a pair of pale yellow circular eye-like prominences, set one on each side of the broad anterior part of its upper surface. These in conjunction with the flattened subtriangular-shaped abdomen impart to this region, according to the observer, a singular similarity to the head of a small snake or goggle-eyed, gecko-like lizard. Lurking at the bottom of its silken tube with nothing but its abdomen visible, this spider suggests to a prospective enemy that it is trespassing upon the home of a reptile and running the risk of being itself destroyed. A similar appearance may be seen in a few other spiders of this family ; in *Cyrtarachne lactea* from East Africa for example ||.

Mr. Saville Kent's ingenious suggestion is worth recording so that it may hereafter be refuted or substantiated by experiment.

In all the cases of mimicry real or imaginary hitherto considered, the resemblance to the model appeals to the enemies' sense of sight. In one possible case amongst spiders the appeal is made to the auditory sense. In South Africa there is a fairly large spider, *Sicarius*, belonging to the Scytodidæ, which is furnished with a stridulating organ consisting of a series of short thick spines on the inner surface of the femur of the palp and of a finely-ridged area on the adjacent outer surface of the mandible. A species found by Simon in the Transvaal lives under stones, lying flattened with legs extended upon the soil. Its movements are extremely slow ; and instead of attempting to escape when seized, it lies still and stridulates, giving out a sound resembling the buzzing of a bee. The behaviour of this spider

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* 'Colours of Animals,' p. 261; see also 'Essays on Evolution,' pp. 367–368, 1908.

† Trans. Ent. Soc. London, 1902, p. 397.

‡ Proc. Zool. Soc. 1902, pt. ii. p. 253.

§ 'Naturalist in Australia,' p. 257, 1897.

|| Pocock, Ann. Mag. Nat. Hist. (7) ii. p. 446, 1898.

is like that of a protected species. Were this so its stridulation would come, like that of the Aviculariidæ, under the category of warning (aposematic) characters. But the resemblance of the stridulation to that of a bee may be pseudaposematic and suggest to would-be aggressors that the spider itself, although harmless, is in reality, like a bee, dangerous to meddle with *.

A possible and oft-quoted instance of aggressive mimicry in spiders was suggested long ago by Trimen, who stated that some Salticidæ imitate crawling flies in their movements and are enabled thereby to approach the insects without alarming them. This view, however, is not in keeping with my own observations upon the visual powers of flies; nor do the hunting methods of the Salticidæ bear it out. For no sooner do they sight a fly than they suspend the alleged deceptive crawling movement, and substitute stillness, followed by a stealthy cat-like creep and a lightning leap over the intervening space. This method would be unnecessary were Mr. Trimen's hypothesis true. If there be, as is possible, mimicry in this case, I suspect it is also protective; and that the spiders benefit by deceiving wasps which, mistaking them for flies, perhaps pass them by as difficult or impossible to catch.

EXPLANATION OF PLATE 32.

Fig. 1. *Ildibaha mutilloides*, Sim., ♂ (after Simon) (p. 260).
2. *Sphecotypus niger*, Perty, ♀ (after Simon) (p. 262).
3. *Myrmecium nigrum*, Perty, ♂ (after Simon) (p. 261).
4. *Myrmarachne plataleoides*, O. P. Cambr., ♂ (after Simon) (p. 263).
5. *Amycicæa forticeps*, O. P. Cambr., ♂ (after Cambridge) (p. 262).
5 *a*. „ „ „ Lateral view with legs removed to show the ant-like profile and the eye-like spot at the end of the abdomen.
6. *Paraplectana thorntoni*, Blackw. (after Simon) (p. 257).
7. „ *walleri*, Blackw. (after Simon) (p. 257).
8. *Araneus coccinella*, Poc. (after Pocock) (p. 257).

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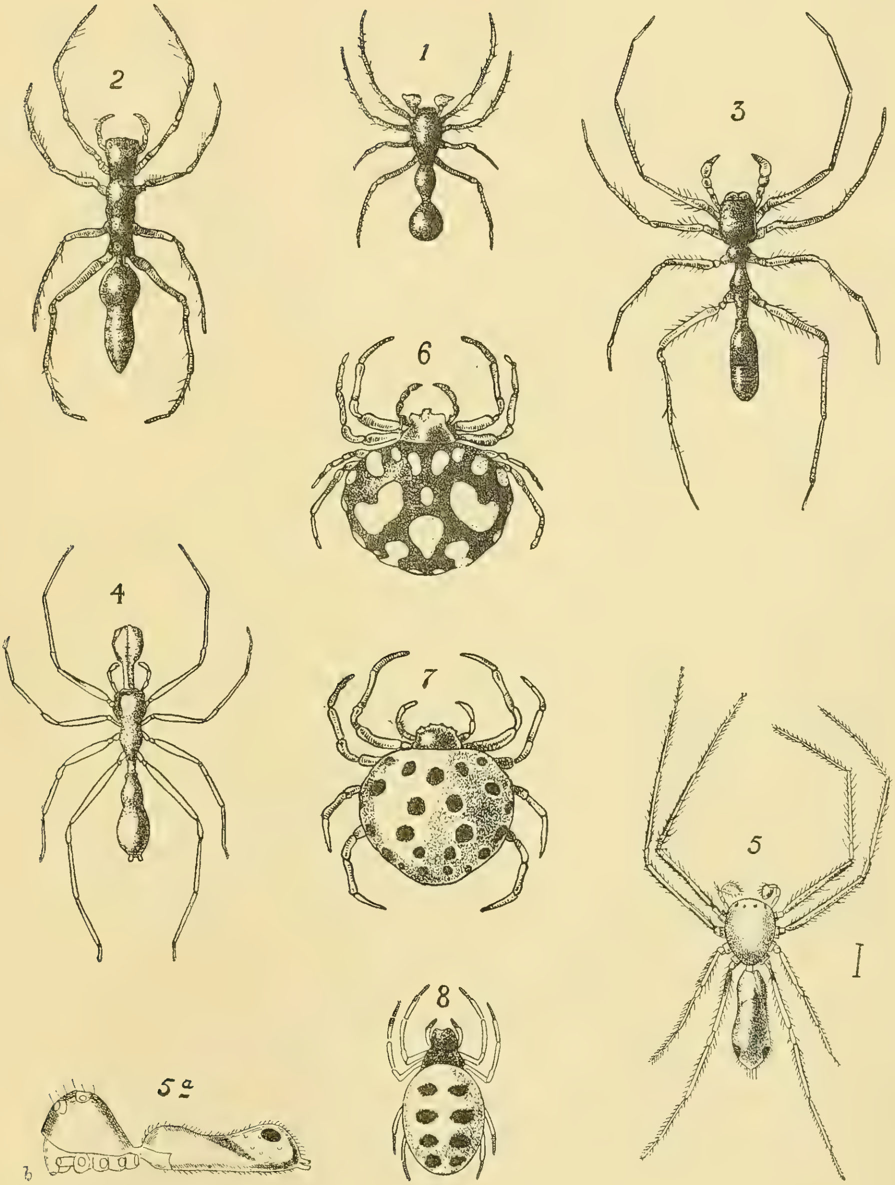
* Pocock, 'Natural Science,' vi. p. 49, 1895.

Probably owing to his writing from memory of this suggestion as to the stridulation of *Sicarius*, Mr. G. A. K. Marshall unintentionally misrepresents me as believing that the stridulation of Scorpions and Mygale Spiders (Aviculariidæ) is pseudaposematic, recalling the shrill, angry buzz of wasps (Trans. Ent. Soc. London, 1902, p. 403). As a matter of fact, I have always believed, and frequently stated the belief, that the stridulation in these two groups of Arachnida is aposematic in exactly the same sense as is the rattle of the rattlesnake. Scorpions can sting and the Aviculariidæ have a poisonous bite and urticating bristles.



Grout, sc.

MIMICRY IN SPIDERS.